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CAPITAL COST CONTROL OF FERTILIZER PLANTS IN DEVELOPING COUNTRIES

ANNEXES

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Preface

This annex contains basic data and information supplementing the analysis of Volume I of the study entitled "Capital Cost Control of Fertilizer Plants in Developing Countries". The annex contains in addition to data and information the questionnaire used as well as some experience from the World Bank with regard to fertilizer projects implemented in developing countries.

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I. QUESTIONNAIRE AND EXTRACTS FROM THE RESPONSES

A questionnaire[1/] was mailed to over 200 selected parties comprising owners, consultants, contractors, associations and government departments who are generally concerned with planning, design, construction of fertilizer projects and manufacture of fertilizers both in the developing and the developed countries.

A total of only 29 responses relating to 25 projects in eleven developing countries and three developed countries were received from various parties, as follows:

- associations 3
- consultants 2
- contractors 6
- owners 18

Projects reported in these responses are given alphabetical letters to conceal their real identity (name, owner, location etc.) in compliance with the request of respondents, i.e. projects A, B, C etc. A country-wise distribution of the various responses as made by various actors is as follows:

Countries	Projects (as reported by actors involved)
C_1 (developing country)	A* (Ow)
C_2 (developing country)	B* (Ow), C (Ow), D (Ow)
C_3 (developing country)	E (Ow)
C_4 (developing country)	F (Cr)
C_5 (developed country)	G (Ow) - 6 allied projects
C_6 (developing country)	H (Ow), I (Ow), J (Ow + Cr)
C_7 (developing country	M* (Ow + Cr), also Ct; part project
C_8 (developed country)	N (Ow)
C_9 (developing country)	O* (Ow)
C_{10} (developing country)	P* (Ow)
C_{11} (developing country)	Q (Ow)
C_{12} (developing country)	R (Cr)
C_{13} (developed country)	S (Cr)
C_{14} (developing country)	T ((Ow), U (Ow)

* = Projects covered by the World Bank Feasibility/Appraisal Report
Ow = Owner, C = Contractor Ct = Consultant, C = Country

1/ A blank sample of the questionnaire is following on pages 3-13.

Relevant extracts from the response received are attached hereto. This information follows the same order as the blank questionnaire. Major issues which appeared frequently in the responses were used to crystallise the real reasons for time and cost overruns and served as basis for the proposed guidelines to minimize the capital cost of future fertilizer projects in the developing countries.

The information extracted from the questionnaires is presented in the following order, wherever applicable:

- General information
- Cost structure
- Major problems: as identified by the owner (and in some cases by the consultant or the contractor)
- Lesson learned: as noted by the owner
- Action suggested for future projects: suggestions proposed by the owner team
- Remarks in respect of the project made by a third party, i.e. World Bank, etc.

Questionnaire on CAPITAL COST OF FERTILIZER PROJECTS

(kindly reply in relation to a SPECIFIC recent project)

1. PROJECT: Name

Owner

Location

Country

Site - Greenfield/Existing - Developed/undeveloped

Extensive site preparation (yes/no), land filling

(yes/no), piling (yes/no)

2. BIDS: Prequalification - Yes/No

Number of Bids

Competitive International Bidding - Yes/No

Tied Aid - Yes/No

If Yes, state source(s) and respective amount(s) please

3. CONTRACTING:

Contractor:

Main process licensors:

Type of contract: Turnkey/Semi-Turnkey/departmental:

Payment: fixed price (lumpsum)

reimbursable

fixed fee and reimbursable

4. TIME SCHEDULE: Kindly indicate month/year: Scheduled Actual

Project conceived

Feasibility study

Bids invited/evaluated

Contract signed

Completion (mechanical)

Start up* - First production

Commercial production

Capacity utilization (1981), %

* Any major problem ? Yes/No if yes, what?

5. CAPACITY/COST

A. Battery limits

	Capacity (Nameplate) Metric Tons/day	Cost Million $		
		Local Currency	Foreign Exchange	Total
Ammonia (gas/naphtha/heavy fuel oil/coal/other) - Kindly specify				
Urea				
Ammonium Nitrate/ Calcium Nitrate				
Sulphuric Acid (S/Pyrites /Gases/Others) Kindly specify				
Phosphoric Acid, (Process)				
Phosphatic Fertilizer: SSP				
TSP				
DAP				
Compound Fertilizer: NPK				
TOTAL PROJECT COST:				

Notes: (1) Kindly EXCLUDE off-sites and infrastructural facilities such as roads, railway siding, workshop, township, etc. (see B below)
(2) Kindly indicate, SEPARATELY, capacity and cost (complete) or utilities; also of storage for various products (as follows):

B. Utilities

	CAPACITY	Cost in MILLION $		
		Local Currency	Foreign Exchange	Total
Power station/Steam generator				
Fresh or saline cooling water system				
Power supply/distribution from existing sources				
Substation for supply from external grid				
Total*				
Storage (in terms of number of days production). Please indicate total storage capacity in bulk and bags.				
Ammonia				
Urea				
AN/CAN				
Sulphuric acid				
Phosphoric acid				
TSP				
DAP				
NPK				
Total*				

* If detailed brakdown is not available, please mark the items concerned and indicate the total cost.

6. COST BREAKUP

	Project cost (in m US$)*		
	Local Currency	Foreign Exchange	Tota
A. Software and personnel services			
License fees			
Process design (basic/frontened engineering package)			
Detailed engineering			
Construction supervision			
Commissioning			
Training			
B. Hardware			
Plant and equipment for battery limits and off-sites (utilities and storage)			
Spares (for ... years)			
C. Construction			
Civil engineering building and structures			
Mechanical erection, electrical and instrumentation			
Supervision			
D. Financial			
Interest on loans			
Financial charges			
Suppliers credit			
Additional cost due to currency fluctuation			
E. Others			
Land - site preparation, including development			
Catalyst/consumables			
Raw materials			
Freight and insurance			
Duties and taxes			
Preliminary expenses			
TOTAL			

* In case of difficulties in specifying amounts, please indicate in percentag of total cost.

7. MAJOR PROBLEMS (Kindly elaborate)

A. With consulting company

(most important): 1

2

3

B. With prime contractor:

(most important): 1

2

3

C. With subcontractors:

(most important) 1

2

3

D. With vendors:

(most important) 1

2

3

8. TIME/COST OVERRUN

	Time, months	Cost, million $
Scheduled		
Actual		
Per cent overrun		

9. MAIN REASONS FOR OVERRUN (kindly elaborate and attach additional sheets if required)

(most important) 1

2

3

4

5

10. IMPORTANT LESSONS LEARNT FROM THIS PROJECT (and how would you apply them to future projects) Kindly attach additional sheets if required.

(most important) 1

2

3

4

5

11. HOW COULD YOU HAVE REDUCED THE PROJECT COST? Kindly indicate this in SPECIFIC terms. Attach additional sheets if required.

(most important) 1

2

3

4

5

12. IF YOU COULD START ON THE PRESENT PROJECT ALL OVER AGAIN, WHAT WOULD YOU DO DIFFERENTLY? - in specific terms - Please add additional sheets if required.

(most important) 1

2

3

13. REMARKS:

Name:

Address:

Telephone:

Telex:

Residential phone (if you do not mind):

ANNEX I.2 EXTRACTS OF INFORMATION ON PROJECTS

PROJECT A

1. General
   - developing country - reported by owner
   - ammonia (930 T/D) + Urea (1600 T/D) plants
   - greenfield, undeveloped site, land filling, part piling
   - tied aid (from 2 developed countries (-15% of total project cost)
   - contractor (developed country) fixed fee plus reimbursable
   - total project cost: $ 426 million (foreign exchange $252 m) estimate $ 249 m (World Bank Appraisal) with foreign exchange $ 142 m.
   - project completion: December 1981, 80 months, 40% overrun.

2. Cost structure (m$)

- software	62
- hardware	103
- construction	79
- interest	36
- duties and taxes	42
- preliminary expenses	40
- land development	17
- currency fluctuation	17
- freight and insurance	13
- housing colony and railway siding	17
	426

3. Major problems

   a. with consultant
      - one of the financial institutions (developed country) insisted on awarding consultary contract to a firm (from developed country) with no experience in management of large fertilizer plants. This contract had to be terminated and the consultant was changed, thus resulting in unnecessary loss of time and money.
      - poor planning
      - lack of knowledge of exact itemwise requirements
      - lack of follow-up with suppliers

   b. with contractor (foreign, from developed country)
      - considerable overrun in reimbursable costs (60% in man-months and 330% in vendor representative costs)
      - no experience on projects of this type
      - lack of proper communication with constructors' head-office
      - inexperience on rotary machines, electrical equipment and instrumentation
      - enormous confusion re: scope of supply by vendors.

   c. with sub-contractors (local and foreign)
      - too many subcontracts (foreign, developed country)
      - major accidents: chemical cleaning solution going into secondary reformer, ammonia storage tank seriously damaged etc.
      - idle time due to non-availability of requisite materials

d. with vendors (foreign, developed and developing countries) - delay in delivery
- confusion in scope of supply

4. Lessons learned

- Contractor must have adequate experience
- Owners team must form a part of the contractor's construction team.
- Select a "model plant" for purposes of training and learning
- Electrical and instrument subcontracts must be on a "package" basis
- Price for specialized equipment (e.g. compressor) should include
    a. erection supervision
    b. pre-commissioning
    c. commissioning
    d. vendors service charges
    e. warranty for 18 months after commissioning
- Adequate storage for inspection of materials received
- Procurement from site with back-up from contractors' home office.

5. For future projects

- Engage a minimum number of subcontracts
- Fixed fee and service charges and a contract ceiling price
- Simpler instrumentation

6. World Bank Appraisal Report on this project anticipated major problems and risks involved giving the following reasons:

- The proposed complex plant considered as formidable undertaking in the country's current state of economic development
- Further equipment price escalation in a strong seller market
- Delays in equipment deliveries from fully booked suppliers.

The report also warned of costly delays in project management.

PROJECT B

1. General
   - developing country, reported by owner
   - ammonia (900 T/D) and urea (1100 T/D)
   - greenfield, undeveloped site, extensive site preparation, land filling/piling
   - total project cost: $ 283 million (foreign exchange $ 82.4) international financial loan: from developed country)
   - departmental execution: purchasing and construction by owner
   - license/engineering through direct negotiations. No competitive bidding
   - mechanical completion July 1982. Commercial production January 1983

2. Cost structure (m$)

a.

- battery limits	175
- utilities	42
- storage and handling	27
- others	39
	283

b. cost elements

- software	36
- hardware	102
- construction	36
- interest	25
- land development	10
- freight and insurance	8
- price escalation	29
- contingency	17
- working capital	15
- others	5
	283

3. Major problems
   - No previous experience on plants of this size
   - Fabrication and project errors of some machines
   - Quality control not so rigid during construction
   - Construction during the "boom" of a major petrochemical complex in the country
   - Engineering/purchasing during the oil crisis
   - Problems during start-up due to:
     . deflective instrumentation and machinery
     . failure of one auxiliary boiler and dirt in the steam generation system

4. World Bank Appraisal Report envisaged project cost of $ 283 million and commercial production Jan. 1, 1981. The project seems two years behind schedule but without any cost overrun. The scheduled 4 years to commercial production was stated to be longer than estimated for similar bank-financed projects elsewhere. However, it was thought of as realistic , considering:

   a. low level of industrialisation in the proposed plant location area
   b. somewhat complicated co-ordination procedure between the two concerned national companies and the engineering companies.

PROJECT C

1. General
   - developing country, reported by owner
   - ammonia (1200 T/D) and urea (1500 T/D) - also sulphur recovery unit (58 T/D) and methanol unit (24 T/D)
   - existing developed site adjacent to a petroleum refinery which furnishes the necessary feedstock (= high sulphur residual petroleum fraction)
   - packaged units from individual suppliers
   - total project cost $ 532 m (foreign exchange = $ 159 m)
   - completion: Feb. 1983. 100% overrun in time and cost. Original estimate 40 months and $ 272 m.
   - major reason for overrun: Pre-operational problems

2. Cost structure (m$) - 5 months before completion

- software	38
- hardware	171
- construction	59
- supervision and pre-operation	81
- interest and repayment during construction	103
- railroad	4
- land development	6
- taxes and fees	9
- others	12
	483

3. Major problems
   - critical equipment was first time deliveries from local suppliers.
   - Late purchase of items (mainly electrical and piping) not originally provided for in the scope of work
   - Problems during commissioning:

   a. Ammonia plant
      - refrigeration unit (from developed country) underdesigned
      - liquid nitrogen wash plant (from developed country) grossly underdesigned
      - shift converter - bad distribution of gas in the catalyst bed
      - HCN stripper - does not meet specifications (25 PPM of HCN in the column effluent)
      - air separation plant (from developed country) spray cooler outlet air temperature over 12°C (against design of 8°C)
      - atomizer guns for gasifiers - life time too short - 200 hours instead of 1200 - 2000 hours
      - instrument air compressor (from developed country) - underdesign and excessive vibration
      - ammonia storage area refrigeration compressor - underdesigned
      - air compressor turbine (from developed country) high vibrations, also does not operate over wide range of speeds
      - nitrogen compressor (from developed country) failure of a twisted blade

- high pressure feedstock pump specified for 150°C (actual: 190°C)
- flare system overdesigned and stock height and function not according to normal established standards
- deionized water system and steam system - water and steam consumption higher than expected

b. Urea plant

- CO_2 compressor turbine (from developed country) - steam leeks through bolt holes
- high pressure ammonia pumps (from developed country) - experimental design, mechanical failures of valve spring, connecting rod pin and brushing
- carbonate pump - low efficiency
- ammonia pumps (from developed country) - damping gets damaged very quickly and the bladder not as per specification
- urea weighing machine (from developed country) - not suitable for hygroscopic material, urea adheres to the wall
- CO_2 compression (from developed country) - gas flow instability in the 2nd casing due to a "rotating still" - also underdesigned.

c. Others

- steam balance - very tight
- elective supply - not completely trustworthy

4. To reduce project cost and operating cost the following were recommended:

- improvements in fuel economy, e.g. use of steam from urea plant during start up to pre-heat boiler feed water
- sampling system to analyse oxygen in the gas auxiliary boiler to reduce excess air required for efficient fuel burning
- recuperation of waste oil
- use of additives carbon oil to reduce deposition of heavy metal high temperature
- utilization of waste fuel gas (from refinery) in auxiliary boiler
- use of heavier feedstock available refinery with appropriate change in plant
- reacceleration of motion devices plunger pump of gasification.

5. For future plants

- better layout
- two auxiliary boilers instead of one
- four gasifiers instead of three
- thrustworthy power supply
- additional compressor (oxygen or nitrogen) preferably motor devices
- improved affluent treatment system
- storage capacity: Feedstock to suit refinery operations, and for ammonia to suit market conditions

6. World Bank Staff Project Report (April 1976): Project cost was estimated at $ 272 million, a basis of prices as of end 1975, including provisions for contingency and price escalation. Price escalation was too low since engineering had already progressed and most equipment already ordered on fixed price basis.

PROJECT D

1. General
   - developing country - reported by owner
   - phosphate fertilizers
     - Sulphuric acid 2 x 1300 T/D - Contractor A (DC)
     - Phosphoric acid 2 x 470 T/D - Contractor B (DC)
     - Triple superphosphate 1 x 1040 T/D) Contractor C (DC)
     - Monoammonium phosphate 1 x 1000 T/D)
   - undeveloped site, extensive site preparation
   - no information on time and cost overrun. Start up July 1980.

2. Cost structure (m$)

- software	48
- hardware	79
- construction	68
- land at site improvements	23
- pre-operating expenses	23
- freight, insurance and taxes	7
- interest during construction	19
- installed cost	267
- working capital	42
Total	309

Phasing of expenditure (m$)

1977	34
1978	88
1979	122
1980	54
1981	15
	309

Costs plant-wise (m$)

- sulphuric acid	43
- phosphoric acid	71
- TSP	36
- MAP	32
- Offsites + utilities	44
	225

3. Major problems: No information furnished.

PROJECT E

1. General
   - developing country - reported by owner
   - ammonia 540 T/D, urea 940 T/D
   - existing developed site preparation and land filling
   - tied aid - one (from developing country) of the four financing sources. About $ 10 million.
   - Contractor (developed country) - fixed fee for design, engineering, procurement, training, erection and start-up
   - project cost $ 181 m (foreign exchange $ 115 m), 20% overrun
   - completion Aug. 1980 - 67 months - 70% overrun
   - commercial production Sept. 1981

2. Cost structure (m$)

- software	33	(includes reimbursables to contractor)
- hardware	72	
- construction	10	
- site preparation	5	
- pre-operating expenses	27	
- freight, insurance and duty	20	
- interest during constr.	12	
- others	2	
	181	

3. Major problems

   a. with consultant (developed country)
   - project manager: performance unsatisfactory and was replaced
   - consultant could have helped owner set up his project organisation

   b. with prime contractor (developed country)
   - delay in organizing project team of head office
   - construction progress unsatisfactory
   - poor performance of expatriate supervisors
   - communication gap between contractors' site office and head office

   c. with sub-contractor
   - poor performance (local and foreign - developed country)
   - poor supervision (local and foreign - developed country)

   d. with vendors
   - cost of rectifying object in their equipment had to be borne by the owner
   - cost of vendor servicemen - excessive technicians and their overtime rate and holiday pay
   - long delays in supply of structural steel and
   - poor quality control at vendors' works.

4. Main reasons for overrun
   - delayed deliveries
   - delay in construction
   - equipment failure.

5. Lessons learned

- Essential to have an expert team for negotiating an equitable contract. Present contract proved most unsatisfactory for the owner
- Contractor liability too mild or none at all (e.g. for excessive use of feed and fuel, to the extent of $ 10 million, during the prolonged start-up period.
- Owner must set up his project team at the earliest stage of project execution.

How could the project cost have been reduced?

- Minimizing delay in completion of the project
- Short commissioning period
- Financing from one source. In present case, owner had to deal with contractors in four different countries and this made the co-ordination job rather difficult.
- Use of proven equipment. Trial of an approved burner one of the critical furnaces caused very heavy waste of feed/fuel during commissioning and delayed the project considerably.

6. For further projects

- higher penalty (for contractor) for delayed completion
- ceiling on charges for contractors' personnel
- contractorial limit on feed/fuel consumption during start-up
- greater control and better inspection of local materials
- continuous audit at the contractors' site office
- greater control over selection of contractors' local staff.

PROJECT F

1. General
   - developing country - reported by contractor (Developed Country)
   - phosphoric acid 220 T/D P_2O_5
   - existing developed site
   - tied aid (developed country)
   - contract on lump sum basis, departmental execution
   - completion (expected) July 1983, 24 months behind schedule (48 months).

2. Cost structure
   - contractor's fee, including past supply $ 9.4 million
   - all other work done by owner, no cost figures furnished.

3. Major problem
   - no information furnished except for the statement:"will not have full extent until project is complete".

4. Main reason for delay
   - slow construction and erection by clients local contractors.

5. Lessons learned

   "will not be able to evaluate extent until project is completed".

PROJECT G

1. General - developed country - reported by owner. 6 different projects all in West Europe
   - departmental executive
   - sites - Vienna, as indicated below

2. Relevant data for the 6 projects

	PLANT	COMPLETION	CAPITAL COST m$	COST OVER-RUN	REMARKS
G1	Fertilizer	1972	8.7	13%	At existing developed site, no extensive site preparation
	Nitrite Acid	1972	2.8		
	Phosphoric Acid-expansion	1972	2.9		
	Utilities	1972	2.5		
		Total	16.9	13%	
G2	Sulphuric Acid, Phosphoric Acid and MAP	1969	20.7	- 5%	Greenfield, undeveloped site
G3	Sulphuric Acid	1981	15.0	4%	At existing developed site
G4	Sulphuric Acid	1974	10.6	7%	At existing developed site
G5	Sulphuric Acid	1970	3.1	11%	At existing developed site
G6	Nitric Acid	1981	11.3	- 4%	At existing developed site
					Cost under-run inspite of 30% time over-run (22 months instead of 17 months).

3. All projects completed on or near scheduled time with nil or nominal cost over-run.

PROJECT H

1. General
   - developing country - reported by owner
   - expansion (Ammonia by 415 T/D and Urea by 680 T/D) at an existing developed site. Plants similar to existing
   - departmental execution, process licensors from developed country, hardware re-imbursable, detailed engineering and procurement through local officers of engineering companies (from developed country)
   - no tied aid, no competitive bidding. Negotiated contracts
   - mechanical completion, June 1981 in 24 months from contract signing. Completed on time but with 10% cost overrun. Project cost: $ 96m, with a foreign exchange element of $ 29m.

2. Cost structure (m$)

   a.

ammonia plant	47
urea plant	34
utilities	15
	96

   b. Cost elements

software	10
hardware	53
construction	10
interest and financial charges	11
duties and taxes	11
catalyst/consumables	1
	96

3. Major problems

   a. with consulting companies (local; for detailed engineering and local procurement)
      - lack of appreciation of cost control
      - tendency of overdesign
      - poor expediting with vendors

   b. with prime contractor
      - (none engaged)

   c. with sub-contractors
      - civil - lack of mechanisation. Material shortages (cement, steel) also price premium in open market (compared to controlled price)
      - piping - too much dependence on manual welding
      - equipment erection - lack of adequate lifting equipment, shortage of good quality skilled tradesmen.

   d. with vendors (mainly local)
      - raw material availability
      - late ordering of raw material and import components
      - lack of appreciation of contractual obligations
      - industrial disputes (freight, developed country also)
      - owner having to assert with solution to technical problems.

4. Main reasons for cost overrun

- 3.8% due statutory price increase in steel, cement and diesel oil, etc.
- 3.7% due currency rate fluctuations
- 1.5% due mobilizing additional manpower resources for expediting, site supervision and commissioning.

5. Important lessons learnt

- ensure timely availability of project funds
- avoid changes
- vigorous and skilful expediting necessary
- obtain commitments from consultants, contractors and vendors
- competent project management team with delegation of authority is imperative
- helping sub-contractors with their problems is advised.

6. To reduce project cost

- maximize fixed cost contracts
- prompt payment for delivered work
- reduce wastage and losses/pilferage
- improve management information system
- prompt action particularly in respect of industrial disputes etc.

7. For future projects

- in-house computer exclusively for project execution is an asset
- better planning of shipment/transport, particularly for imported materials
- streamlining of documentation
- adequate attention to commissioning management.

PROJECT I

1. General
   - developing country - reported by owner
   - ammonia 900 T/D + urea 1500 T/D
   - greenfield, undeveloped site requiring extensive site preparation, land filling and piping
   - tied aid
   - semi-turnkey execution. Consultants (developed country)
   - project cost $ 228m (foreign exchange $ 111m), 22% overrun.

2. Cost structure ($m)

   a.

- ammonia	63	
- urea	29	
- utilities	43	
- storage	4	(most likely:
	139	excluding construction, interest, etc.)

   b. cost elements

- software	23	
- hardware	115	
- construction	31	
- interest, etc.	33	
- others	38	
	240	
- less	12	credit for pre-operational production, inventory and construction supplies
	228	

3. Major problems

   a. with consulting company (developed country) - wrong indent of refractory materials. Mistake not detected at time of inspection.

   b. with vendors
   - delayed deliveries of major items (imported from developed country), particularly compressors, large-sized towers, piping and bulk materials
   - delayed deliveries from local vendors due industrial disputes, and power cuts. Steam generation plant delivered 12 months late.

4. Main reasons for overrun
   - change of feedstock from furnace oil to naphtha
   - port strike and later heavy congestion at port
   - heavy power cut during construction/commissioning due severe draught conditions in the project area.

5. Lessons learnt
   - project management ought to be able to anticipate and consequently deal with unforeseen situation.

PROJECT J

PART 1 - reported by the owner

1. General
- developing country
- ammonia 1350 T/D + urea 1800 T/D
- greenfield, undeveloped site
- departmental execution, 3 contractors from developed country and 2 from developing country. Fixed price for engineering and reimbursible for services
- completion December 1981 (68 months instead of 54), cost over-run
- project cost Rs. 4450 million. No over-run (?). Tied aid.

2. Cost structure (Rs. million)

- software	544
- hardware	1168
- power station	317
- construction	249
- interest, financial charge and currency fluctuation	1079
- duties, taxes, etc.	436
Total	3793
Other expenditure	657
Overall project cost	4450

3. Major problems

a. with consulting company
- co-ordination with different agencies
- too many inspection agencies.

b. with prime contractor
- lack of experience
- too many revisions
- delays in details of piping.

c. with sub-contractors
- insufficient mobilization (expediting process)
- manpower shortage
- no proper material accounting.

d. with vendors
- delays in delivery
- equipments not conforming to standards
- tendency for extra claim even for minor changes
- wrong certification of material from foreign vendors(developed country).

4. Main reasons for over-run

- delay in engineering; mainly piping and instrumentation by engineering contractor. Also modifications/revisions at site
- delay in importing steel plates due to strike in Europe
- delay in local deliveries (compressor, pump, vessels, and heat exchangers)
- delay in importing fabricated piping
- port strike.

5. Lessons learnt : The following should be achieved

- clearer and well-defined contracts
- realistic project time schedule
- more responsibility to local consultants.

6. For future projects

- move Head Office to project site at an early
- no change in top management (even Board of Directors) in mid-stream
- select only one contractor for overall project co-ordination
- better expediting with foreign suppliers
- more and smaller erection sub-contracts at site.

PART 2 - reported by one of the three contractors from (developed country)

1. General
   - no tied aid
   - contract signed March 1979. Project completion October 1981
   - Fixed fee ($ 14.7m) and reimbursable ($ 69 hardware).

2. Major problems

   a. with client
      - no authority in respect of local supplies/services
      - insufficient local engineering personnel in prime contractor's home/office
      - extremely complicated and cumbersome import procedures.

   b. with sub-contractors (site)
      - delay in detailed engineering
      - shortage of skilled manpower.

   c. with vendors of imported materials
      - unreliable quality assurance/inspection leading to replacement of imported materials at a late stage of the project execution period.

   d. with local vendors
      - strikes and industrial disputes
      - bought-out items did not match requirements in many cases
      - time consuming co-ordination of battery limit connexions/ conditions.

3. Main reasons for overrun
   - late supply of imported and local materials and equipment
   - shortage of skilled manpower for erection
   - delay in import licenses.

4. Important lessons learnt
   - assign competent main contractor(s) at the earliest stage possible
   - early placement of orders for long delivery local equipment
   - minimum number of local vendors/workshops to streamline material procurement and quality assurance
   - there should be no preference for public sector suppliers.

5. To reduce project cost
   - uniform design specifications/requirements for the entire plant
   - competitive and early tendering for local equipment to enable timely action for import license in case of unrealistic high price and/or long delivery
   - erection contract (local) should have an escalation clause
   - more mechanical sub-contracts (5 instead of 3) to reduce labour problems
   - simplify and speed-up procedures for import license.

6. For future projects
   - adequate authority for main contractor for effective co-ordination
   - competent group of clients' engineers in contractors' office during the entire engineering phase
   - project team of prime contractor should be present locally during detailed engineering phase.

PROJECT K

1. General
   - developing country - reported by owner
   - ammonia 600 T/D, urea 1000 T/D, naphtha-based
   - greenfield, undeveloped site, extensive site preparation, land filling and piling
   - departmental execution - process licenses and engineering/ procurement/construction supervision by a foreign (developed country) firm, on fixed fee by reimbursable basis
   - contract signed October 1967, commercial production November 1976, 5 years later than scheduled
   - overrun in time 180%, in cost 163%
   - project cost, approximately $ 923 million.

2. Cost structure (m Rs)

   a. Plant costs

- ammonia	247
- urea	147
- utilities	63
- other project expenditure	466
	923

   b. Project cost elements

- software	221
- hardware (incl. spares)	283
- construction	139
- interest, financing charge and currency fluctuation incident site	157
- land, site preparation and development	22
- catalyst/consumables	14
- freight-insurance	14
- duties and taxes	38
- others	35
Total	923 (foreign exchange m. 233 Rs.)

3. Major problems

   a. with consulting company (who also procured the foreign portion of the hardware from a developed country)
      - limited experience with ammonia plant using centrifugal compressor
      - unproven equipment, poor workmanship, failure, e.g.
        1. pumps, H.P. boiler feed water pump
           boiler circulation pump
           H.P. carbonate charge pump
        2. teflon seated ball valves in hot naphtha vapor line had to be replaced with globe valves
        c. purge gas from the synthesis loop was never used (as intended) as reformer fuel
      - inadequate steam balance design
      - very tight design with no margin.

b. with sub-contractors

- the sub-contractor for erection of flue gas boiler abandoned the job at a very late stage
- labour unrest.

c. with vendors

- delayed deliveries, both local and imported materials by as long as 27 - 48 months.

4. Main reasons for overrun

- delay in land acquisition
- shortage of steel for fabrication of equipment
- some major items procured locally for the first time were delivered considerably late
- labour problems
- major problems during start-up/commissioning:
  (a) critical equipment failure (see previous section)
  (b) seal and tube leakages of reformer gas boiler
  (c) defective speed indicator of synthesis gas turbine
  (d) power - irregular supply.

5. Lessons learnt

- the consultant selected should have had prior experience in similar/identical plants
- no tied credits, least of all for critical equipment and machinery
- avoid multiplicity of agencies for design, procurement, etc.
- make liberal provision for utilities (safety margin in design)
- captive power plant must be included.

6. To reduce project cost

- judicious selection of consultant and of critical equipment
- pre-qualified vendors
- ensure good industrial relations
- project scope clearly defined in detail
- realistic estimate with provision for escalation - local and global
- competent project management team
- clearly defined responsibility of consultant/contractor and owner.

7. For the next project

- choose a standard size plant
- use proven equipment and machinery
- realistic estimate on basis of in-house data and data from reliable sources.

PROJECT L

1. General
   - developing country - reported by contractor
   - ammonia 900 T/D, urea 1550 T/D (Fuel-oil based ammonia plant)
   - greenfield, undeveloped site requiring extensive site preparation, land filling and piling
   - turnkey contract (developed country), fixed fee for services and reimbursable for hardware
   - contract signed mid 1974, mchanical completion mid 1978, commercial production end 1979.

2. Cost structure (m$)

- software	22	foreign exchange element = $ 73m
- hardware	145	
- construction	20	
	187	

(Incomplete data. It is not certain whether this represents the plant cost or the overall cost, although logically it could represent the turnkey plant cost).

3. Major problems

   a. with vendors
   - delayed deliveries due to labour problems
   - defective equipment:

   (1) synthesis gas compressor (from developed country), ammonia - vibration
   (2) air separation unit (from developed country), cold box, explosion.

4. Main reasons for overrun
   - 6 months due to air separation unit accident
   - 6 months due to delay in equipment supply - labour problems at the works
   - 12 months due to short supply of coal and fuel oil (feedstock).

5. Lessons learnt (by the contractor)
   - must collaborate with a local engineering company.

6. Future projects
   - either to undertake the project execution on turnkey vasis.

PROJECT M

PART 1 - reported by the owner

1. General
- developing country - reported by owner
- ammonia 1000 T/D, urea 1725 T/D, (gas-based ammonia plant)
- greenfield, undeveloped site requiring extensive site preparation, land filling and piling
- turnkey contractors (developed country) on basis of fixed fee and reimbursable
- contracts signed end 1975, mechanical completion end 1978, commercial production mid 1979. Completed on time
- project cost $ 208 million - within budget
- built-in advantage: present project is a duplicate of a previous one at the same site.

2. Cost structure (m$)

- ammonia	126
- urea	46
- utilities	11
- storage	25
	208 (foreign exchange $ 153 m)

3. Major problems

a. with prime contractor
- contractor's warehouse control system was not effective
- excessive (lost/stolen/unaccounted for) materials
- surplus materials at end of the project execution were not properly identified.

4. Lessons learnt
- performance test guarantees for utilities/auxiliary must be clearly spelled out
- owner must oversee the materials control system, also ensure the use of construction equipment rented by the hour on a reimbursable basis.

PART 2 - reported by the contractor - for urea plant:

(Only additional or conflicting information is included here).

- project completed in 33 months instead of the scheduled 36 at a cost of $ 29.14 m (scheduled: $28.96) - represents the fixed fee and the cost of partly imported hardware.
- same vendors, as the previous project (of which the present is a duplicate at the same site), proved to be of great advantage.

To reduce project cost, it is advised that the following be effected:

- world-wide bidding for big items
- purchase small items from the country of origin of the engineering company

PART 3 - reported by Technical Advisor from developed country

1. General - conflicting information

- the work involved replacement of the prilling system of an existing urea plant with a poor granulation system
- existing, developed site but with extensive site preparation, land filling and piling. Completed June 1981 (in 36 months), 12 months behind schedule (100% overrun)
- project encountered 50% overrun in cost.

2. Major problems

a. with contractor (=owner)

- inadequate inspection of major equipment prior to shipment
- inadequate experience of project manager and his team (the job was their first project).

b. with vendors

- delayed delivery
- failure in meeting equipment specifications.

3. Main reasons for overrun

- development/demonstration type project
- change in project manager during project execution.

4. Lessons learnt

- better to use an experienced (outside) engineering contractor or consultant
- qualified project manager is imperative.

5. For future project

- better equipment specifications and bid evaluations.

PROJECT N

1. General
   - developed country - reported by owner
   - ammonia 1350 T/D, urea 1000 T/D
   - greenfield, undeveloped site with extensive site preparation, land filling and piling
   - contractor (developed country) on basis fixed fee and reimbursable
   - mechanical completion, early 1979 in 51 months instead of scheduled 36 months (42% overrun)
   - project cost: $ 288 million (15 per cent foreign exchange)

2. Cost structure (m$)

   a. Individual plants cost

- ammonia	186
- urea	72
- utilities	12
- storage	18
	288

   b. Cost elements

- software	32
- hardware (incl. spares)	74
- construction	105
- interest, currency fluctuation	47
- land development	9
- prelim. expenses	5
- raw materials (incl. catalyst)	7
- freight and insurance	9
	288

3. Major problems

   a. with prime contractors

      - lack of project co-ordination at all phases from basic design to commissioning
      - underestimation of qualities in civil, electrical, instrumentation, insulation and painting

   b. with subcontractors

      - insufficient manning

   c. with vendors

      - numerous design and manufacturing errors particularly with rotating equipment, e.g. coupling assemblies and mechanical seals had to be fitted corrected and (most serious) support of a steam turbine which lacked rigidity gave rise to bearing and coupling failures which had to be corrected by brazing in the field.

4. Major reasons for overrun

- delay in procurement and delays in civil design
- industrial relations problems
- weather (adverse) conditions

5. Lessons learned

- proper staffing by client and by main contractor
- owners team in contractors' office should be strengthened
- more emphasis on contractors' industrial relations right from the start and owner to maintain effective control thereof.

6. To reduce project cost

- Prime contractor must produce at the outset a detailed integrated schedule of all activities
- Monitoring of the above by the owners project team for early detection of slippage is imperative.
- Minimize number of options for product handling/despatch.

7. For future projects

- Contractor must provide the track record of his Project Manager Designate and Construction Manager Designate periodically.
- Owner's project team must include an experienced engineer for monitoring progress against the schedule
- Briefing the contractors' project team including the industrial relations staff on the industrial relations situation with particular reference to communication systems is essential.

PROJECT O

1. General
   - Developing country - reported by owner
   - Ammonia (1000 T/D), urea (1500 T/D)
   - Greenfield developed site, but requiring extensive site preparation, land filling and piling
   - Tied aid
   - Contractor (developed country), lump sum fixed price contract, departmental execution envisaged
   - Project completed in 72 months instead of scheduled 24 months
   - Project cost m$ 181 with 200 per cent overrun
   - Commercial production in May 1982.

2. Cost structure (m$)

- software	6
- hardware	58
- construction	125
- other charges	12
	201

3. Major problems

   a. with consulting firms
      - delay in receipt of technical information
      - delayed engineering and that of a local firm needed corrections

   b. with contractor
      - slow progress, average 4 per cent per month instead of scheduled 7 per cent
      - contract not well defined and therefore programme suffered

   c. with subcontractors
      - steel structure delayed by one year due to lack of capacity
      - ammonia sphere delayed by local subcontractor due to inexperience
      - clarifloculator below specifications - leak in the concrete foundation.

   d. with vendors
      - delayed receipt of technical information
      - increased prices due to devaluation
      - delayed supplies due to late payments by owner
      - long procedures for imported equipment

4. Main reasons for overrun
   - change in government
   - change in internal organization of the owner's company
   - modifications/repairs of equipment due to change of location
   - increased engineering work load (for adjustment/corrections)
   - delayed deliveries from suppliers
   - rapid turnover of personnel in the local engineering firms
   - lack of supervision by the owner at the beginning of the contract
   - shortage of qualified manpower due to major constructions in the country.

- Shortage of cement
- Lack of effective construction programme.

5. Lessons learned

- The scope must be clearly defined at the outset
- Early ordering of long-delivery items (e.g., control instruments)
- Proper storage facilities available before hand
- Minimizing changes once engineering and other work starts
- Better quality control
- Quicker checking of suppliers drawings/specifications
- Clearly defined scope in case of overlapping suppliers
- Close control on delivery and cost of hardware
- Minimize personnel turnover
- Better communications and human relations between owner and contractor.

6. To reduce project cost

- Mobilize appropriate human resources
- Strict supervision of contractors
- Fixed price for hardware
- Close and frequent review of foreign contractors' man/hour rates
- Establish early and adequate storage system for supplies received at site.

7. For future projects

- Strict control on suppliers, local and foreign
- Frequent cross-checking in various areas throughout project construction
- Quick approval of execution instructions
- Instructions must be clear and precise
- Strict inspection of critical equipment and instruments
- Execute strictly in accordance with plans
- Exact definition of engineering scope and supply services
- Storage area not to interfere with work area
- Streamline receiving and despatching system
- Cross check detail engineering drawings before start of construction
- Use unit price as far as possible
- Different contractors for civil work and for technical erection
- List of items missing to be drawn and acted upon
- Clear knowledge of funds available at various times
- Firm commitment and better human relations owner/contractors.

PROJECT P

1. General
   - developing country - reported by owner
   - ammonia (1000 T/D), urea 1725 T/D
   - greenfield undeveloped site with extensive site preparation and piling, but not land filling
   - tied aid from two developing countries and also suppliers credit from a third developing country
   - contract signed 1977, mechanical completion end 1981. Total period, 48 months (33 per cent overrun)
   - Semi-turn-key execution with fixed fee plus reimbursable contract
   - Project cost $ 296 (25 per cent overrun) foreign exchange, $ 178 m.

2. Cost structure (m$)

   a. Plants cost

- ammonia	59
- urea	31
- utilities	41
- storage	13
	144 (incomplete)

   b. Cost elements

- software	37	
- hardware	108	
- construction	51	
- financial	33	
- freight + insur.	19	
- catalyst/consum.	12	
- duties and taxes	9	
- land development	7	
- other	20	(it could be working capital and/or contingencies)
	296	

3. Major problems

   a. with prime contractor
      - insufficient planning at all stages
      - insufficient preparation at home office
      - too much work (design and procedures) at site
      - site staff not authorized to modify design and specification of home office

   b. with subcontractors
      - local civil contractors had cash flow problems.

   c. with vendors
      - cement shortage
      - delayed deliveries for foreign equipments by 2-10 months

4. Main reasons for overrun

	$ million
- transport (unrealistic estimate by the general contractor	11
- interest	12
- unprecedented escalation	12
- construction	9
- taxes	5
- administration, pre-establishments	5
- technical assistance	4
- railway siding (not originally provided for)	2
	60

5. Lessons learned

- Engineering design must start immediately on contract signing.
- Funds and payment procedures must be ready at contract validity time.
- Prior investigation of local conditions (power, water, transport, vendors, contractors, etc.)
- Owner to be involved in cost control from the very beginning.

6. To reduce project cost

- Advance engineering and procurement
- More use of local supplies
- Employ more of local foremen and supervisors.

7. For future projects

- Pay more attention to
  a. engineering, procurement and commissioning schedule
  b. process design of utilities
- Owner's personnel must take active part in
  a. supervision
  b. quality control
  c. pre-commissioning.

8. World Bank appraisal report

- Project cost estimate $ 260m (foreign exchange $ 173 m). On stream scheduled) mid-1980.
- Project sponsors: local party plus one of the largest fertilizer producers in a developed country
- The latter were to provide an experienced project manager.

PROJECT Q

1. General
   - developing country - reported by owner
   - sulphuric acid (pyrites-based) 1500 T/D, phosphoric acid 2 x 600 T/D, diammonia phosphate and NPK compound fertilizers 2 x 65 T/D
   - Greenfield site with extensive site preparation
   - Turn-key contractors (from developed country) fixed fee and reimbursable basis
   - Contracts signed end 1981, mechanical completion end 1984 (expected)
   - Project cost (estimated) $ 400 million (foreign exchange $ 280 million). No overrun so far.

2. Cost structure (m$)

- sulphuric acid	157
- phosphoric acid	69
- DAP and NPK	49
- Utilities	34
- storage	89
	400

- software	7.5%
- hardware	55.2%
- construction	37.3%
	100.0

3. Lessons learned
   - more optimized off sites design
   - less stringent environmental restrictions
   - more realistic specifications of final product quality

PROJECT R

1. General
   - developing country - reported by contractor (developed country)
   - sulphuric acid plant (300 T/D) based on sulphur
   - developed site without much site preparation necessary
   - contract on turn-key basis, fixed lump sum price
   - total project cost $ 8.9 m (foreign exchange $ 5.3 m)
   - commercial production March 1980.

2. Cost structure (m$)

- software	1.65
- hardware	3.45
- construction	3.24
- interest and currency fluctuation	0.11
- catalyst/consumables	0.10
- freight and insurance	0.35
Total	8.90

3. Major problems
   - no consultant
   - no prime contractor

   a. with subcontractor (from developed country)
      - lack of skilled tradesman
      - poor productivity, probably due to long working hours (12 hours per day with one day off every 2 weeks)
      - safety standard not up to the mark.

   b. with vendors
      - late delivery of an item from developed country

4. Main reasons for overrun
   - late delivery of an imported item

5. Lessons learned
   - A local partner (active agent) is a must
   - In the absence of help by the owner, the contractor had to rely on local tax consultants
   - Clear and specific stipulation in the contract regarding local taxes should be known
   - No clear-cut boycott stipulation was received
   - Practically no local sources of supply
   - Difficult to service mechanical guarantees without continued presence
   - Arbitration/litigation almost impossible because of local laws.

6. To reduce project cost

   Prior knowledge of local working conditions

7. For future projects

   Must have a local agent of sufficient stature.

PROJECT S

1. General
   - developed country - reported by the contractor (developed country)
   - ammonia (1360 T/D), urea (1090 T/D), ammonium nitrate (1000 T/D) (gas-based ammonia plant)
   - existing developed site with no extensive site preparation, but some piling required
   - contract on turn-key basis, payment reimbursable
   - commercial production end 1978, overrun of 1 1/2 months over the scheduled 40 months completion. Cost 9 per cent below scheduled.

2. Cost structure (m$)

   a. Individual plant cost

- ammonia	63
- urea	29
- ammonium nitrate	15
- utilities + storage	63
	170

   b. Plants cost components

- software	28
- hardware	48
- construction	94
	170

3. Major problems

   none mentioned

4. Main reasons for overrun

   - three months slow-down by the owner due to shortage of feedstock

5. Lessons learned to reduce production cost

   none

6. For future projects

   none

PROJECT T

1. General
   - developing country - reported by owner
   - ammonia (600 T/D), urea (750 T/D), phosphoric acid (250 T/D, 100 per cent P_2O_5), TSA (1400 T/D), DAP (880 T/D), gas-based
   - existing developed site but with some site preparation and piling
   - turn-key contract with 3 contractors (all from developed countries)
   - commercial production 1979 in 120 months instead of the 36 scheduled previously
   - project cost 106 million dollars (283 percent cost overrun)

2. Cost structure

- ammonia	14.4
- urea	7.0
- phosphoric acid	5.4
- TSP + DAP	3.8
- Utilities	6.6
- Others	69.0
Total	106.2

3. Major problems

   a. with consultant
      - lack of definition for the entire project

   b. with prime contractors
      - incomplete programme
      - inadequate inspection
      - specifications not clear-cut

   c. with subcontractors
      - same as above

   d. with vendors
      - substandard equipment
      - inadequate materials

4. Main reasons for overrun
   - lack of clear definition
   - constant changes
   - lack of decision making
   - lack of central supervision
   - type of contract
   - subcontractor unable to implement proposed programme

5. Lessons learned
   - clear definition and specific developing plan
   - clear definition of programme
   - realistic plan for work and its implementation
   - more control necessary at all stages

5. To reduce project cost (see previous section)

6. For future project (use the experience gained on this project)

PROJECT U

1. General
   - developing country - reported by owner
   - ammonia storage facility and some other facilities
   - existing developed site requiring site preparation, land filling and piling
   - contractor (developed country) fixed price contract, semi-turn-key basis
   - project completed in 54 months instead of the scheduled 24.
   - project cost 38 million dollars (31 per cent cost overrun)

2. Cost structure (m$)

- ammonia storage	8.9
- others	28.9
Total	37.8

3. Major problems

   a. with consultant
      - technical specifications not completely defined
      - delay in bid evaluation
      - delay in delivery of major equipment

   b. with prime contractor
      - none

   c. with sub-contractor
      - none

   d. with vendors
      - delayed delivery.

4. Main reasons for overrun
   - delay in engineering details
   - delayed material delivery
   - changes

5. Lessons learned
   - better project control and project management
   - clear definition of basic engineering

6. To reduce project cost
   - better control at all stages
   - clear and well defined technical specifications

7. For future projects
   - clear concept of the project
   - entrust construction and engineering to a specialized country.

ANNEX I. 3 SPOT VISITS
LATIN AMERICA

The reports of the spot visits to three Latin American countries, Brazil, Mexico and Venezuela, are included herein. The visits were helpful in getting a first hand "feel" of problems relating to execution of fertilizer projects in these countries and also to understand the structure of the industry. The highlights of the visits are summarized below.

Brazil

The general policy is to maximize local purchases of services and equipment. As an example for the Laranjeras plant, the local participation constituted 35 per cent for the first unit and 75 per cent for the duplicated second unit. In the second unit nearly 75 per cent of the entire hardware, including all vessels, heat exchangers, reactors were procured locally.

The price of local hardware is usually competitive except for highly sophisticated items like ammonia converter which were made in the country for the first time. For example, the cost of locally produced converters was almost three times that of imported ones. This is, perhaps, the initial price one has to pay for indigenization. Local hardware is also competitive in the international market except, of course, for highly sophisticated items as the ammonia converter mentioned above.

The second fertilizer project at Laranjeras was completed in 5 1/2 years perhaps one year later than desirable. Overall, however, it can be said that the project authorities were able to exercise good cost control as a result of proper co-ordination during erection of the plant.

The foreign contractor (from developed country) submits a list of local vendors and this has to be vetoed and approved by the owner company or his local engineering wing. The procurement and co-ordination is also overseen by the owner.

Some of the lessons learned for the future are:

- greater flexibility in steam generation
- better inspection during local fabrication
- possibility of a Brazilian firm as the main contractor.

Venezuela

The entire fertilizer industry is government-owned and the product is distributed at subsidized rates. The older plants were executed on turn-key basis and the newer one on semi-turn-key basis or departmentally.

Delayed deliveries from local suppliers have been one of the reasons for long completion periods and cost overrun. For one of the projects executed, the final overall cost was $ 283 million as compared with the initial estimate of $ 142 million. This borders the cost of one of the earlier projects when the principles of sound project management and in particular the value of "time control" was not fully recognized.

The entire civil engineering construction, electrical work and mechanical erection is done by local contractors. Detailed engineering is also done locally either by national firms alone or with foreign collaboration.

Delays of fertilizer projects execution have mainly been affected because of

- lack of clear and specific project definition
- lack of quick decision
- over-centralization of supervision
- delayed delivery of local hardware particularly due to technical and quality control problems.

Chemical production, and presumably fertilizers as well, are now tied to the Andean Pact under which different productions are assigned to different countries within the pact. The projects proposed include joint ventures with multinational companies. They are also planning to have joint venture fertilizer projects in third countries, i.e. Colombia.

Mexico

The fertilizer industry is now entirely nationalized since all the private fertilizer units were taken over by the government during the period 1962-1967.

The feedstock to the fertilizer industry is made available at international prices so that it can compete on actual terms.

Two of the major problems in implementing a recent project have been due to mechanical failures, i.e. in case of the turbine, the blades were not up to the specifications and ultimately they had to be changed by the supplier, and in the case of the urea reactor, the valves are found to be corroded. Both of these items were supplied by a vendor in a developed country.

Fertilizers are a priority industry in the country and plant location is connected with providing infra-structure as part of social development of particular areas. This of course could have jacked the overall cost of the project.

Pre-planning has been one of the major problems in delayed execution of projects. This not only leads to delays (direct), but indirectly causes subsequent changes that are necessary. This is now sought to be corrected for future projects.

A central office is now responsible for the elaboration and supervision of feasiblity studies, detailed engineering design, procurement, co-ordination of construction as well as provision of technical assistance to operating plants.

ANNEX I.4 ABSTRACTS FROM INTERVIEWS WITH CONTRACTORS/CONSULTANTS

Some contractors were visited, by prior arrangement, between December 1981/January 1982. In many cases, the contractors asked for more time to consult amongst their colleagues locally as well as in other countries. To by-pass the implications, they were requested at the end of each meeting to furnish a brief outline of their views on the subject matter with particular emphasis on ways to minimize capital cost of future fertilizer projects in developing countries. Almost all the contractors kindly responded to the request. The highlights from minutes of the meetings and from the "briefs" received subsequently are included in this section. As far as possible, the wordings of consultants/contractors have been retained, though in a considerably shorter format. The overall impressions of those visits are:

a. All parties were most co-operative, but some more than others. It was clear that in each case they had already done some spade work beforehand not only among colleagues at the same location, but also by inviting (by telex/letter) relevant information from their head office (i.e. USA) and appropriate subsidiaries elsewhere. Meetings were generally at fairly senior level (vice-president).

b. It was emphasized by most that the present issue is a complex one and that no simple universal answer and/or solution exists. Each case must be studied in depth to get at the heart of the problem. A superficial look at this issue could easily lead to absurd conclusions and wrong solutions. This could only make matters worse.

c. Contractors generally and obviously blame the project authorities (and the concerned governments) for the "run-away" costs. Informally some of the contractors interviewed agreed that some developing countries may have, at times, been overcharged. Few added that it was, however, their own doing (developing countries'). One went so far to say that contractors were also, at times, suffered from bad deals and at least one of them went bankrupt as a result of a single contract.

d. Total project cost is meaningless unless the entire scope is completely spelled out. No two projects are ever the same. Unless comparison is made for similar projects, the whole exercise (of comparison, analysis and solution) may be one of futility. Hence the need for thorough homework.

e. The parties met anxiously await UNIDO's findings on this vital subject and in particular the Guidelines thereof for ultimately, they will be involved in translating these into practice to the mutual benefit of all the parties involved in planning and executing fertilizer projects.

CONTRACTOR A

1. Knowledgeable clients take advantage of the competition on the market place. Every six months they obtain an up-date (through a questionnaire) on the major contractors and entrust work to those contractors who are short of work. Developing countries could do likewise but may need an outside consultant to act as their "arm" in the absence of an in-house project engineering team.

2. Extent of increase in project cost due to various factors:
   - 5 - 10 per cent Project finance
   - 10 - 20 per cent Freight, insurance, transport
   - 20 per cent Contingency for guarantees and liabilities.

3. Suggestions to owners for reducing cost of future projects:
   - reimbursable - type contract (avoids overproviding risks)
   - go easy on liabilities - contractors stake in terms of share and profit is small in relation to project cost
   - exploit market place competition as 1. above
   - use management contractor or consultant to supplement own project team, if necessary.

CONTRACTOR B

1. The cost of hardware for process plants is not much different whether the plant is in Timbuktu or the U.S. Gulf Coast. It is other considerations that largely influence the project cost.

2. Other considerations include
   - financing (source and conditions) is the crux for final cost
   - lack of infrastructure and human resources
   - procedures and bureaucracy: bidding/customs, etc.
   - delays due to formalities, construction mobilization, etc.

3. In some countries the socio-economic cost considerations generally overshadow the cost of bare process plants. The desired location may have no rail facilities, no power and very little water because of their desire to provide employment for people in the area. In addition, port facilities, many miles away, have to be built to accommodate export shipments of fertilizer.

4. A contractor needs to know, apart from the product desired:

   a. Is the project to be a world-scale facility to export most of the fertilizer or is it to be a smaller facility to serve only the needs of one country? In the former case, the adequacy of existing land shipping facilities to deliver raw materials to the plant and to deliver products to a port and port facilities must also be analyzed.

   b. What raw materials are locally available and what must be imported? (This will determine what fertilizers should be produced)

   c. Has the site been selected or should investigations be conducted of a number of sites?

   d. Information on energy and non-energy operating costs vs. capital costs trade-off for guidance of front-end engineering effort. Optimization considerations differ for each developing country.

   e. Whether the project is to consist only of a grass roots production facility or whether an infra-structure is to be included.

   f. Review bidding practices tied to financing, process licensing, and guarantees. As alternative, consider process selections studies, licensing and front-end engineering package prior to bid solicitations. Front-end engineering would include site specific matters, offsites,

transportation considerations, etc. so as to limit bidder's risk.

g. If a client, or financing institutions, insist on overall performance guarantees for a total grass roots project, then the contractor's risk is substantially increased and hence the project cost. Therefore, we believe that a client should not insist on overall performance guarantees.

h. To contain/reduce project cost:
   - Adequate homework, beforehand, is a must.
   - Front-end engineering is desirable prior to bidding.

CONTRACTOR C

1. Infra-structure including transportation can add substantially to the cost.

2. Most contractors can achieve project targets up to FOB shipment. Major labour problems in vendors can, of course, result in delays to critical equipment. This happened in the 1974 crisis in the United Kingdom, during the "three-day working week" period.

3. To achieve a reliable construction estimate, a minimum of sixty per cent of the detailed engineering should be completed, in order to give accurate quantities - concrete, steel, piping, buildings, electrics, etc. also a detailed investigation should be made of the conditions in the country where the plant is to be located - port installations, government regulations, custom/tariff payments, transportation, labour, workshops, productivity, etc.

4. These pre-requisites very often are not completed, due to developing countries' desire to conserve foreign currency. They request a turn-key bid without a prior engineering contract. By so doing, they obtain better credit terms and also do not risk venture capital on feasibility studies. However, this is probably why many projects fail.

5. The contract is weighed against the contractor who has taken an excessive risk in bidding. Sometimes he makes unexpected profits, but usually the client selects the lowest bidder, and this results in a loss situation. The contractor will, under these circumstances, seek to reduce his costs to a minimum. This could be through reduction of expatriate supervisors, choice of lowest cost sub-contractors, delays in committing staff to construction until complete delivery of materials and contractural disputes with the client.

6. To minimize project costs
   - feasibility study with estimate of ± 15 to 20 per cent
   - detailed engineering and material enquiry stage with estimate of ± 5%
   - preparation of bid documents for selected equipment or process units, with construction being separate
   - implementation stage - complete detailed engineering, supply and construction
   - the client should assign staff to work with the management consultant or contractor as part of the project team controlling each phase. The client should apply his local knowledge and muscle to assist the project.
   - Many of the cost overruns arise from initially poor preparation and inadequate estimates.

CONSULTANT D

1. In most cases, high cost can be quantified and explained. Main causes: scope, clients' ignorance. Contractor is seldom to be blamed.

2. Additional costs over and above Western Europe in some Gulf Arab States due to such items as freight, insurance, air-coolers, site labour, essential and optional expatriate supervision, other design factors range from 36 per cent to 50 per cent.

3. High selling costs for a serious consultancy assignment. In one country consultants were called for discussions but on arrival found that one person concerned was not available (called for another assignment) and would not be back but for one week. Later the client (knowing of the consultants' annoyance) decided to visit London with a team of negotiators. Again the consultants will have to spend a few days without any assurance of the job. Ultimately someone has to pay for such "sales efforts".

CONTRACTOR E

1. Scope factors contributing to additional costs in developing countries:
   a. Climate, geology/topography, elevation above sea level
   b. Availability/reliability of water, power, transportation
   c. Regulations: environmental and safety
   d. Plant labour customs/practices: canteens, medical facilities, change houses, permanent housing
   e. Availability of maintenance equipment and materials: shops, warehouse
   f. Local standards and construction practices, i.e. concrete structure vs. steel
2. Additional cost on account of hardware:
   a. Imported items: export packing, freight, import duties, source of financing
   b. Local items: often more costly (protected market) or of lesser quality, longer/uncertain deliveries
   c. Terms: Onerous contracts in terms of warranties or guarantees - delays in payments to suppliers/contractors
3. Additional cost on account of construction:
   a. Labour: efficiency, construction practices, labour camps, worker transportation
   b. Supervision: qualified local contractors but expatriates supervision
   c. Construction tools and equipment: Partly imported.
4. Additional cost due to contractor's home office in regard to:
   a. Process packaging: expatriates if engineering done locally, Language/system of measurement
   b. Detailed engineering (local): unfamiliar codes and regulations, efficiency, expatriate supervision, language/system of measurement
   c. Purchasing: divided responsibility, purchasing/engineering at different locations
   d. Project management: divided responsibility, language, communications, travel
5. To reduce capital costs: pursue and/or have:
   a. untied credits
   b. standardise plant capacities

c. standardise plant process and design - simple to suit local conditions
d. standardise plant equipment supply and spares
e. relax onerous contract conditions and project procedures
f. strong project management team (owner/consultant)
g. single responsibility for engineering and purchasing
h. consultant to represent owner (in early stages of development)
i. site chosen with minimum civil costs, infrastructure, requirement etc.

CONTRACTOR F

1. Engineering

   a. Plant design fully specified and agreed before contract award
   b. Site soil study available beforehand
   c. Process design should be agreed before engineering commences and no process changes mid-stream
   d. Plot plan should allow adequate space for storage and fabrication shops. This is particularly important when the site is a hydraulically filled, reclaimed area in a low lying district with no possibility of enlargement without major cost involvement.

2. Procurement

   a. Procurement procedure should be prepared and agreed before hand. World Bank procedures require considerably more manpower than normal commercial projects.
   b. Critical materials and proprietary equipment: these should be specified and agreed to in the contract with a list of nominated suppliers.
   c. Pre-qualification procedures: The vendors' list should be prepared at the earliest post-contract award date, based on the contractor's experience of international procurement. The lenders could review the list to ensure that all countries participating in the funding are included.
   d. Approvals: to save time, lenders' representative with the necessary level of approval authority be located in the contractor's offices.

3. Shipping and transport

   a. Shipping to, and transporting inside third world countries should be very carefully studied and firm agreements reached with forwarding agents, shippers and in-land transport companies as soon as possible.
   b. Some ports are prone to labour disputes, power cuts and inadequate off-loading facilities. Congestion surcharges are normal.
   c. Contractors should have permanent shipping co-ordinators in the main ports in the clients' country where the plant is to be built.
   d. Payment for shipping should be through a revolving fund to reduce delays incurred with letters of credit.

4. Accounting and disbursement procedures

   a. Lenders' disbursement procedures are unnecessarily complex and cumbersome, leading to late payments.

b. These delays have chain reaction: orders are not firmed up until advance payment, shipments are delayed.

c. It is recommended that the use of payment by a revolving fund is established at the beginning of a project.

d. Need of experienced expatriate accountants to ensure obtaining funds in good time.

5. Construction

a. Construction philosophy must be agreed upon as soon as possible after award of contract. The split between local and foreign subcontractors should be defined clearly.

b. The subcontractors should include materials such as cement, aggregate, sand and reinforcing steel.

c. Equipment being supplied piece meal (e.g. heaters, waste heat recovery systems, cooling towers) should be ordered on a supply and erect basis.

d. Training in the mechanical trades; welding; pipe fitting, etc. Instruments and electronic work is generally best left to expatriate subcontractors with expatriate staff.

e. Employing expatriate working foremen who could show the local staff how to do the work as well as how to direct their labour.

f. Temporary facilities must be provided/arranged by the contractor to ensure there are no restraints to the employment of expatriate and national labour.

6. Client relations

a. The client must clearly define his organisation as due of his advisors and their levels of authority and responsibility.

b. Adequate means of communication such as telex and telephone

c. Owners' representatives in the home office of contractors should have the authority to approve immediately orders and payments.

7. Lender liaison

a. The lead lending agency should appoint their own project manager capable of acting as mediator for disputes.

b. At the earliest time, meetings should be held between the lender, the client and the main contractor to define where equipment and material can be purchased and will be purchased under the lender's rules. More flexibility should be given as to where equipment can

be purchased, for instance, tying of construction equipment to the A.I.D. loan was costly and time consuming, as in many cases electric motors etc. on proprietary construction equipment manufactures in the USA was incompatible with the supplies at the site, and better and cheaper equipment could have been obtained in a number of cases from European sources which were not covered by that particular fund.

c. Insistence on local purchases should also be less rigid.

8. Overall

a. simple and clearly defined contracts and procurement procedures

b. no unnecessary stringent specification for products to be covered guaranteed by the contractor

c. plants should be small (in capacity) and simple.

d. simple instrumentations. Avoid electronic and complex computer systems

e. Impress (on the client) the need for quick decisions.

f. Expatriate staff should be fully briefed.

g. Pay-offs, if encountered, are an added cost element.

CONTRACTOR G

1. The major cost elements and their respective contribution to the total project cost of a fertilizer plant (or for that matter any process plant) are:

software	20 per cent
hardware	40 per cent
construction	40 per cent

2. For a typical developing country (with no engineering and fabrication facility) the first two items will remain the same (except for freight and transport elements) at all locations (developing or developed) and the main difference will arise in case of construction. The difference will vary from case to case and each case will have to be examined in depth in order to allow for quantification.

CONSULTANT/CONTRACTOR H

1. The high cost (20-35 per cent) is mainly due to the lack of infrastructure, increased scope of work and interference by the financing institutions.

2. Credit tied to one country as source of supply can lead to a 20 per cent price increase. Desirable to have a credit package permitting competitive bids from several countries. An untied credit package may involve several organisations and its servicing may be time consuming (leading to higher costs) due to bureaucratic procedures (advertising, pre-qualification). Some bidders even refrain from quoting, this leading to an uncompetitive situation. Higher equity proportion (to credit) would be conducive to impose greater discipline.

3. Five to seven years lead time can be due to the financing pattern, low capability level, restricted infrastructure and lack of disoipline.

4. It takes two to four years to reach 100 per cent capacity utilisation from start-up.

5. Best training is on the job. It is desirable to have an experienced operating company for the first few years of operations during which time locals can be trained on the job.

CONTRACTOR I

1. Factors which can be quantified:

   a. tropicalisation: to cover the additional cost of equipment to cater for:
      - operation in extreme climates
      - earthquake resistant if required, and
      - export packing

   b. Shipping, port fees, CIF charges and in-land transport to site

   c. Civils: could be similar to that in the developed countries but must be investigated before hand.

   d. Construction: location is important. It may be close to a main urban area (e.g. Newcastle in the United Kingdom, Lagos in Nigeria) or in a totally remote site, e.g. Nigg Bay in the United Kingdom. The difference between the two is the cost of establishment of a temporary site township and all the necessary domestic facilities for the construction crew.

   e. Commissioning: additional travel and subsistence expenses of supervising engineers

   f. Engineering: The necessity of site visits and the inevitably extended project time scale having an effect upon the efficient use of man/hours.

   g. Exclusions: These below the line costs of financing, bonding, duties, etc. vary greatly, but represent a significant percentage in the cost of a third world project.

   h. Adequate/liberal spare parts - much more than for a site from where standard items can be procured quickly.

2. Factors which cannot be quantified:

   a. The invitation to bid (ITB) may well contain rigid definitions of engineering standards.

   b. In case of an additional plant at an established site, matching of standards for valves, electric motors, switch-gear, cables and instruments, piping and vessels can be a major problem.

   c. A long validity date of the tender and protracted negotiations have a major bearing on the contract price.

   d. Infrastructure, including transport, cranage etc. can be <u>partly</u> qualified

   e. The client's staff may be well educated in the form of university

degrees but have probably not had exposure to industry and, for example, do not know the difference between one type of steam trap and another, nor when a butterfly valve (low cost) may be used instead of a conventional control valve (high cost).

f. Any engineering change or change of specifications can be costly, particularly if such a change is imposed by the client late in the engineering phase. A "simple" change of motor specification nine months into the engineering phase could alter a great deal of detailed engineering drawings and cost a great deal of money.

g. The client may take a considerable project responsibility himself, while he may not be capable of doing so. Take over of even little contracting at a late stage can be quite expensive.

To summarize, additional costs for third world projects are due to:

- remote location
- the effect of an uneducated client.

In total, these two factors could add 50 per cent to the project total erected cost.

3. To reduce capital cost of future projects, the following should be considered:

- prequalifications of bidders
- reasonable (to both parties) contract
- pay the contractor well - it pays off in the long run;
- reimbursable for hardware and even for construction - avoids over provision of risk/contingency by the contractor
- quick and high capacity utilisation
- a competent consultant to act as client's arm.

CONTRACTOR J

1. The three major cost components of capital projects (in developing and perhaps also in developed countries) have been escalating thus:

- engineering and supervision, 6 per cent/year
- hardware 6 to 8 per cent/year
- construction, 20 to 30 per cent/year.

2. Economy of scale is lower at higher capacity and could even be negative at very high capacity. Also the operating/raw material costs have been escalating much faster than capital cost, so much so, that the former constitute a major portion (well over 50 per cent) of the production cost. For these reasons there is a very strong (technical and commercial) case for medium size (rather than world scale) plants for developing countries where the infrastructure (e.g. transport) is inadequate and/or inexpensive.

CONTRACTOR K

1. Plants can be built either on complete turn-key basis (entire responsibility resting with the contractor) or on a departmental basis, wherein the client/owner becomes the project manager and subcontracts (for services and/or hardware) most of the work/supplies to a number of contractors/suppliers.

2. Turn-key can prove cheaper (in the long run) since one draws upon the "know-how" of the contractor. In case of departmental execution (for sake of learning/training) one has to pay the "entrance fee" for the "learning curve". The developed countries have done so in the last part of the 19th century whereas the developing countries are doing so now. This explains the extra cost of fertilizer projects in the developing countries.

3. In many cases the owner appoints a single project manager and relies on the various local subcontractors interfacing with each other without much planned control of labour or materials. This extends the construction period far beyond the normal and increases the overall investment cost.

4. There seems to be a trend back to turn-key type contracts but with restrictions on the use of foreign labour and of maximising local manufacturing and fabricating facilities. These can be more expensive.

5. There is a compensating factor of the advantageous financing and aid facilities that plant owners in developing countries receive from the governments of developed countries.

6. The total project cost could be reduced by spending a little more initially at project definition stage by employing an international consultant/contractor who could also act as the client's project manager. This is until such time that the client can develop his own project team.

CONTRACTOR L

1. General considerations

a. The cost depends on plant location and on the degree of industrialization of plant site. Plants built on site where already infrastructure is available, good quality equipment and materials purchased locally and specialized and competitive erection companies found in nearest areas, investment costs are not too different from Europe.

b. In third world countries, where most of hardware has to be imported or where local labour was scarce or poorly specialized and where even all accommodation facilities had to be provided, investment costs are higher than expected. This in spite of the fact that the hourly labour costs, which represent more than 30 per cent of total investment, are lower. Other factors for higher cost: expatriate supervisors, higher shipping costs, and custom duties on imported equipment and materials. However, skilled labour in some of the developing countries (e.g. India, Pakistan, Philippines and South Korea) is not only cheap but also highly productive provided there is close supervision.

2. Quantitative: Major cost elements of fertilizer projects:

- software 20 per cent
- hardware 50 per cent
- construction 30 per cent

First two items are the same (except for freight and insurance), irrespective of the location. The main difference is in case of construction. The components, their contribution and cost ratio, developing/developed country (roughly):

- 2,0 materials
- 0,5 labour - local
- 0,8 " - others
- 2,0 " - expatriate
- 2,0 supervision, expatriate, including accommodation etc.

Such factors, if established for each location, may provide the key in the present assignment.

3. Cost estimates

Assuming 100 as the cost of equipment and materials ex-works (and this figure does not depend on the location of the plant), the final project cost for three typical locations is worked out as:

	Europe	Pakistan	Libya
	%	%	%
Equipment and materials	100	100	100
Transport, custom duties	6	17	14
Civil works	10	25	30 1/
Erection	48	55 2/	113 1/ 3/
Supervision	6	8	10 1/
Engineering	19	21	21
	189	226	297
Cost factor	1	1,19	1,57

The major increases over European costs appear on civil works, erection and supervision. The big increases in Libyan costs may be caused by the particular location in a desert area which required full accommodation facilities.

4. To reduce project cost, use direct hiring (for civil and erection) with own erection equipment (purchased/hired on a selective basis, since some of the equipment is required during operation/maintenance) rather than the usual method of subcontracting. But this requires a strong and experienced project team.

1/ Including camp accommodation

2/ On direct hiring basis

3/ On subcontracting basis.

CONTRACTOR M

1. The rapid escalation in the cost of fertilizer projects in the developing countries is not caused for sure by a stronger profit orientation of plant suppliers in industrialized countries as it might be suspected by some investors in the developing world.

2. It is predominantly due to substantial time and cost overruns experienced by the contractors within their usually fixed price contracts. New contracts will always reflect past experience and the contractor must take into account, also pricewise, of the particularities of the customer's country.

3. Main reasons for time and cost overruns:

   a. In many cases, data furnished by the client with regard to soil conditions, quality and safety of local supplies, standard of housing for expatriate personnel, time required for procedures of the local administration etc., did not prove reliable. This necessitated:

      - spending more time and money to establish exact data
      - taking over services, e.g. camp management, transportation, etc.
      - more man-hours for project management, local supervision, etc.

4. The clients' top management is usually very competent, but the middle management has a lower degree of professional expertise and working experience leading to:

   - reluctance to innovative technical features
   - safety-first thinking with regard to contractual interpretations, etc.

5. The existence of a client's consultant is generally welcome, however:

   - scope of activities and responsibilities must be clearly defined.
   - Consultant must be accepted by the working level of the client.

6. Substantial infrastructural development means more time and cost.

7. Increased local supplies/services mean longer delivery periods, more inspection personnel, provision for own experts to remedy defective performances of local suppliers, etc.

7. Excessive bureaucracy which is a well known problem

8. The burden of high capital costs becomes still heavier if the plant cannot be operated at its planned capacity.

(PROCESS PLANT) ASSOCIATION N

Major factors for high cost of fertilizer projects in developing countries are:

- lack of infrastructure
- need for expatriate supervision and skilled labour
- delayed completion due to bureaucratic procedures, vague contracts, split-up responsibility
- lack of qualified subcontractors
- bureaucratic procedures.

Table A.1 Capital Cost Structure Elements

COST ELEMENTS OF FERTILIZER PROJECTS		TURN-KEY PLANT COST		OTHER PLANT COST ELEMENTS	ADDITIONAL COST ELEMENTS CHARGED TO THE PROJECT
		Battery Limits	Off-site Facility		
MAIN COST ELEMENTS OF THE PROJECT / PLANT COST COMPONENTS		-Principle process equipments. -Secondary equipments and auxiliary materials. -Civil engineering and errection work. -Freight and taxes.	-Utilities units and distribution system -Storage and material transfer facility. -Control and maintenance facility. -Civil engineering and errection work. -Freight and taxes.	-Preliminary and preoperation activities (feasibility study, site development, training of operators, preparation and material for start-up operations etc.) -Interest -Insurance.	-Contingencies (for delays, price escalation, currency fluctuation, change in scope of work, extra inventory of spares. -Out-of-plant boundary infrastructure -Management -Engineering/Marketing training.
PRINCIPAL COST COMPONENTS	SOFTWARE TECHNOLOGY	-Front end engineering (including licenced patents) -Detail engineering. -Technical management for execution: procurement, inspections, monitoring and cost control, construction supervision and contract coordination		-Feasibility study -Training programme for operators.	-Technical management -Training programme for engineering and marketing. -Detail engineering and management for out-of-plant infrastructure.
	HARDWARE TECHNOLOGY	-Plants and equipments (processing units and auxiliaries including steel structures, fittings etc.). -Piping, electrical and control equipments etc. -Spare parts		-Material and spare parts for first charge (loading) of the plant during commissioning (start-up operations).	-Out-of-plant boundary (fence) infrastructure equipment and material. -extra inventory of spare parts.
	CONSTRUCTION	Labour, constructios and material equipments for -Civil engineering work. -Mechanical engineering (errection) work. -Piping work. -Electrical, instruments, insulation installation and connections.		-Site preparation	-Civil engineering work in connection with out-of-plant boundary infrastructure.
OTHER COST ITEMS		COST ITEMS USUALLY ASCRIBED TO PRINCIPAL COST COMPONENTS: Transportation and freight charges (including insurance), taxes, custom duties, interest.		-Balance of interest -Insurance	-Contingencies

Table A.2 Comparison of erected costs of plants USA cost = 1.0

As of Jan. 1	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Belgium	0.58	0.68	0.65	0.73	0.94	1.07	1.00	1.01	1.10	1.18	1.36	1.21
Denmark	0.64	0.73	0.71	0.76	0.97	1.06	1.01	0.98	0.98	1.10	1.13	1.05
France	0.57	0.61	0.61	0.68	0.83	0.85	0.93	0.89	0.87	0.96	1.02	1.04
Germany	0.62	0.71	0.77	0.81	1.08	1.02	0.98	0.99	1.02	1.12	1.26	1.13
Italy	0.58	0.63	0.63	0.66	0.78	0.86	0.88	0.81	0.82	0.91	1.01	1.01
Netherlands	0.60	0.6	0.72	0.75	0.97	1.04	1.05	1.05	1.12	1.13	1.22	1.14
United Kingdom	0.58	0.62	0.66	0.69	0.72	0.77	0.81	0.70	0.72	0.80	0.94	1.08
Australia	0.62	0.62	0.66	0.67	0.87	0.92	0.89	0.94	0.85	0.87	0.84	0.90
Canada	0.83	0.87	0.86	0.82	0.90	0.92	0.95	1.05	0.98	0.87	0.90	0.90
Japan	0.38	0.40	0.39	0.45	0.54	0.58	0.55	0.59	0.65	0.82	0.79	0.77
Norway	0.72	0.79	0.83	0.87	1.09	1.16	1.16	1.28	1.25	1.29	1.31	1.32
Sweden	0.86	0.87	0.90	0.95	1.17	1.24	1.18	1.24	1.13	1.19	1.26	1.29
U.S.A.	←					1.0						→

Source: Engineering Costs and production economics, 6 (1982), 273.

Table A.3 Location cost index - Various countries

(USA = 100)

Country	Type of plant	Year	Index
Algeria	P	1970	111
Australia	G	1970	120, 105
Belgium	P	1970	100
	G	1970	94
Brazil	G	1970	110
France	P	1970	100
	G	1969	94, 86, 91
	G	1970	91, 98
India	P	1970	123
	G	1970	135
Iran	P	1970	116
Italy	P	1970	95
	G	1969	89, 86
	G	1970	86
Japan	G	1969	82, 83, 95
Netherlands	G	1970	92
Peru	G	1970	104
Saudi Arabia	G	1976	140
Spain	G	1970	100
Sweden	G	1970	100
Taiwan	S	1961-5	100
	C	1961-5	100
Turkey	P	1970	115
United Kingdom	P	1970	95
	G	1969	90, 91
	G	1970	91, 103
West Germany	P	1970	100
	C	1969	88
	G	1970	88, 95
ECM	P	1965	95
Underdeveloped countries	P	1965	125
Underdeveloped countries (with financing)	P	1965	145
Developing country	FR	?	123 - 160

Source: The Cost Engineer, 19 (4, 5, 6) 1981

C = complex; G = general; P = petrochemical, S = simple, FR = fertilizer plants and refinery

Table A.4 Location factors
(Basis USA = 1,00/year)

Australia		1.3
Austria		1.0
Belgium		1.0
Canada		1.15
Central Africa		2.0
Central America		1.0
China	(imported element)	1.1
	(indigenous element)	0.55
Denmark		1.0
Ireland		0.8
Finland		1.2
France		0.95
Germany		1.0
Greece		0.9
Holland		1.0
India	(imported element)	1.8
	(indigenous element)	0.65
Italy		0.9
Japan		0.9
Malaysia		0.8
Middle East		1.1
Newfoundland		1.2
New Zealand		1.3
North Africa	(imported element)	1.1
	(indigenous element)	0.75
Norway		1.1
Portugal		0.75
South Africa		1.15
South America	(North)	1.35
South America	(South)	2.25
Spain	(imported element)	1.2
	(indigenous element)	0.75
Sweden		1.1
Switzerland		1.1
Turkey		1.0
United Kingdom		0.9
United States of America		1.0
Yugoslavia		0.9

Source: Process Economics International, Vol. I, No. 3, Spring 1980.

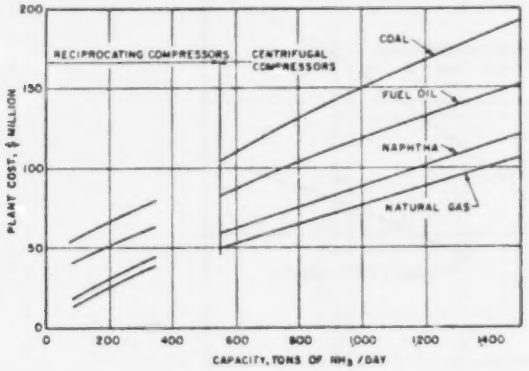
Notes: 1. A factor should be increased by 10% for each 1,000 miles, or part of 1,000 miles that the new plant location is distant from a major manufacturing or import centre or both.

2. When materials or labour, or both, are obtained from more than a single source, the appropriate factors should be prorated accordingly.

ANNEX II. OTHER RELEVANT DATA AND INFORMATION

B. Figures

Figure 1 Estimated turn-key plant cost for ammonia plants as affected by capacity and feedstock



Basis: Industrial location in developed country, Turnkey costs = battery-limits cost plus 50%.

Notes: The most reliable data are for natural gas-based and naphtha-based plant with capacities of 550, 900-1,140, and 1,360 tpd. Data for smaller plants and other feedstocks are more speculative because few such plants have been built.

Figure 2 Effect of type of feedstock and plant capacity on production cost of ammonia

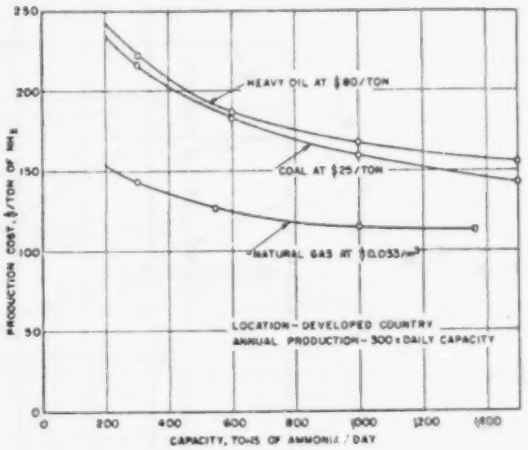

HEAVY OIL AT $80/TON
COAL AT $25/TON
NATURAL GAS AT $0.053/m³
LOCATION - DEVELOPED COUNTRY
ANNUAL PRODUCTION - 300 x DAILY CAPACITY
PRODUCTION COST, $/TON OF NH3
CAPACITY, TONS OF AMMONIA / DAY

Figure 3 Estimated investment cost of urea plants as related to capacity

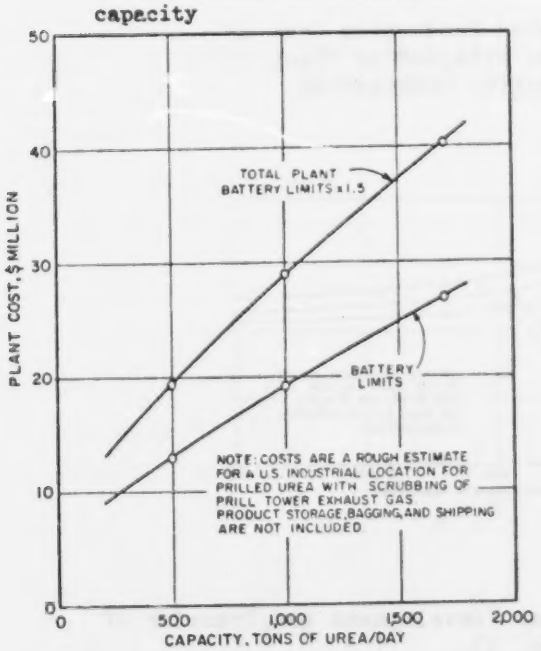
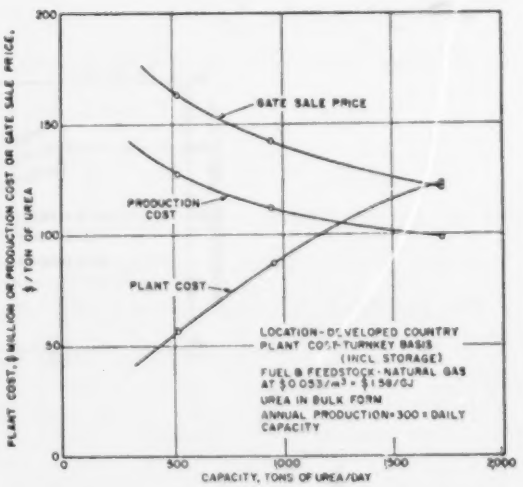

TOTAL PLANT BATTERY LIMITS x 1.5
BATTERY LIMITS
NOTE: COSTS ARE A ROUGH ESTIMATE FOR A U.S. INDUSTRIAL LOCATION FOR PRILLED UREA WITH SCRUBBING OF PRILL TOWER EXHAUST GAS. PRODUCT STORAGE, BAGGING, AND SHIPPING ARE NOT INCLUDED
PLANT COST, $ MILLION
CAPACITY, TONS OF UREA/DAY

Figure 4 Plant cost, production cost, and gate sale price for urea produced in an ammonia urea complex as affected by capacity


GATE SALE PRICE
PRODUCTION COST
PLANT COST
LOCATION - DEVELOPED COUNTRY
PLANT COST - TURNKEY BASIS (INCL. STORAGE)
FUEL & FEEDSTOCK - NATURAL GAS AT $0.053/m³ = $1.58/GJ
UREA IN BULK FORM
ANNUAL PRODUCTION = 300 x DAILY CAPACITY
PLANT COST, $ MILLION OR PRODUCTION COST OR GATE SALE PRICE, $ / TON OF UREA
CAPACITY, TONS OF UREA/DAY

Source: UNIDO Fertilizer Manual "Development and Transfer of Technology," Coming Ma[illegible]

Figure 5 Capital cost of sulphur-burning Sulphuric Acid Plants, Double Contact, U.S. or European Location

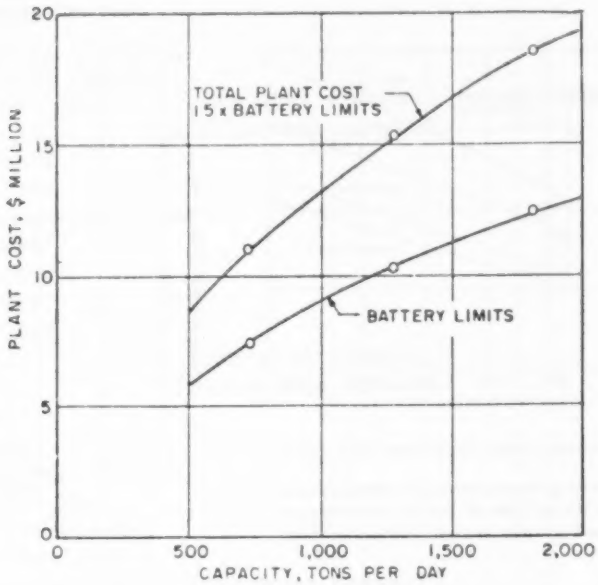
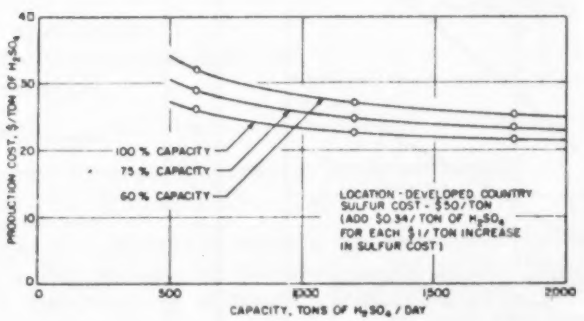
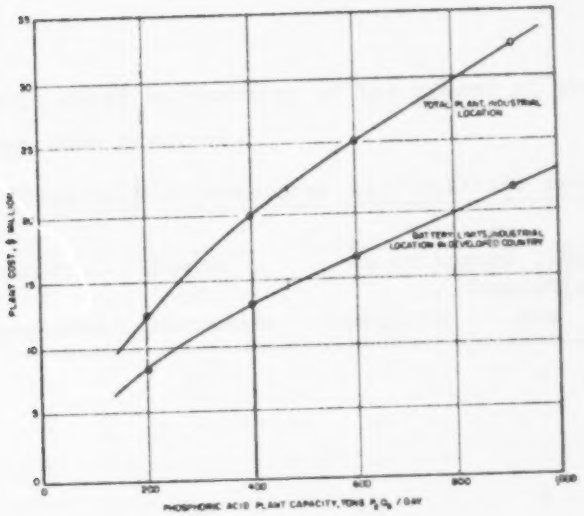


Figure 6 Estimated Production Cost of Sulphuric Acid as Affected by Plant Capacity and Capacity Utilization



Source: UNIDO Fertilizer Manual "Development and Transfer of Technology", Series No. 13.

Figure 7 Estimated Cost of Wet-Process Phosphoric Acid Plants



Source: UNIDO Fertilizer Manual "Development and Transfer of Technology" Series No. 13.

ANNEX III. WORLD BANK EXPERIENCE WITH REGARD TO FERTILIZER PROJECTS IMPLEMENTED IN DEVELOPING COUNTRIES

The World Bank has been actively involved in financing numerous fertilizer projects in the developing countries. It is estimated that nearly 1/4 of all new projects in developing countries have included finance from the World Bank.

1. Overview

The following table gives an overview of the number of projects where the World Bank has been involved.

Table A.5 Role of World Bank - Investment in fertilizer projects

	Loan m$	Number of projects	Number of countries	As of August 1980		
				Completed	Completion due	Completion later
- 1973	300	19	17	-	-	-
1974-1977	1000	-	-	-	-	-
1978	200	4	-	-	-	-
Aug. 1980 (cumulative)		27	11	13	6	8

Before sanctioning finance for a particular project, the World Bank prepares a thorough feasibility appraisal of the same. At the end of the project performance, an audit report is also prepared to highlight the major problems, if any, encountered during execution. Such a report, of course, includes not only the total completion time but also the actual cost in comparison with the estimated cost in the appraisal report. The summary of 22 such fertilizer projects is given in table A.6.

2. Major cause for overrun

Table A.6 below also indicates the major causes of delay/overrun of the major projects in different countries. A separate analysis of the World Bank assisted projects, completed during the period 1970-1980, shows the following major causes of delay in project completion (see table A.7).

Table A.6 Summary of projects sponsored by World Bank

	Date of completion	Months to completion		Project cost, m$		Major causes for delay
		Apprais. report	Actual estimate	Apprais. report	Actual estimate	
Bangladesh						
Project 1	Oct. 80	34	59*			Soil/compaction + project management
Brazil						
Project 1	Aug. 80	34	52*			Materials not to specifications
Project 2	Dec. 80	39	59*			Late delivery of equipment
Egypt						
Project 1	Jun. 80	37	64*			Late delivery, civil works
India						
Project 1	Jan. 70	37	34	68	65	- - -
Project 2	May 73	36	41	70	71	- - -
Project 3	July 76	33	55	41	56	Materials shortage and management
Project 4	July 77	35	53	95	138	Late delivery, damage
Project 5	Mar. 78	32	48	57	83	Late delivery
Project 6	Dec. 78	41	58	166	187	Late delivery, local equipments
Project 7	Jan. 80	45	61	181	168	Change in feedstock
Project 8	Dec. 75	-	-	15	21	- - -
Indonesia						
Project 1	Sept. 74	30	34	67	77	Late appointment - technical advisor
Project 2	Dec. 76	32	31	166	165	- - -
Project 3	Aug. 77	30	26	157	130	- - -
Mexico						
Project 1	Oct. 80	32	56*	-	-	Civil works, currency devaluation
Morocco						
Project 1	Oct. 76	36	40	136	148	Civil works
Pakistan						
Project 1	Sept. 79	28	52	85	171	Late delivery, floods political unrest
Project 2	Feb. 72	-	-	71	77	- - -
Romania						
Project 1	Sept. 80	38	59*			Late delivery, change of scope
Turkey						
Project 1	March 77	36	44	107	137	Change in project management and project team

* Mechanical completion from date of effective control

Table A.7 Major factors contributing to Delay

Factor	Percentage
Late delivery of equipment	19
Management constraints	11
Unforeseen circumstances	11
Late appointment of engineers	9
Scope changes	8
Erection/Civil work delays	8
Late completion of basic design	8
Shortage of skilled personnel	7
Shortage of bulk materials	50
Delays in finalizing procurement	5
Others	9
	100

Overall, nearly three-fourths of the projects were delayed because of late mechanical completion and one-fourth because of problems encountered during commissioning and stabilization.

3. Remedies

In order to prevent cost overrun for future fertilizer projects, one must take into account the lessons learned from the past projects.

For the guidance of our publications programme in order to assist in our publication activities, we would appreciate your completing the questionnaire below and returning it to UNIDO, Division for Industrial Studies, P.O. Box 300, A-1400 Vienna, Austria

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Q U E S T I O N N A I R E

Capital cost control of fertilizer plants in developing countries
Statistical Appendices

	(please check appropriate box) yes	no
(1) Were the data contained in the study useful?	☐	☐
(2) Was the analysis sound?	☐	☐
(3) Was the information provided new?	☐	☐
(4) Did you agree with the conclusion?	☐	☐
(5) Did you find the recommendations sound?	☐	☐
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